Application of Suomi-NPP Green Vegetation Fraction and NUCAPS for Improving Regional Numerical Weather Prediction

Jonathan L. Case[1], Emily B. Berndt[2], Jayanthi Srikishen[3], and Bradley T. Zavodsky[4]

Short-term Prediction Research and Transition (SPoRT) Center

[1] ENSCO, Inc., [2]NASA Post-Doctoral Program, Marshall Space Flight Center (MSFC), [3] USRA, [4] NASA/MSFC

Introduction

- NASA SPoRT is working to incorporate Suomi-NPP products into its research and transition activities to improve regional numerical weather prediction (NWP)
- Daily global VIIRS green vegetation fraction (GVF) are used to improve the representation of vegetation in the Noah land surface model (LSM) over existing climatological GVF to better simulate:
  - Land-atmosphere energy exchanges during anomalous weather/climate regimes
  - Temperature, moisture, and precipitation features, esp. during warm season
- NOAA Unique CrIS and ATMS Processing System (NUCAPS) temperature and moisture retrievals are assimilated into the Gridpoint Statistical Interpolation (GSI) system to demonstrate:
  - Assimilation of hyperspectral IR profiles with appropriate error characteristics
  - The impact on a summer pre-frontal convection case

Background on GVF in Regional Modeling

- SPoRT MODIS-based real-time GVF for land surface modeling and regional NWP
  - CONUS+ domain at 0.01-deg resolution since 1 June 2010
  - Updated daily with Direct Broadcast swaths of NDVI from Univ. of Wisconsin
  - Ingested into NASA Land Information System (LIS) and Weather Research and Forecasting (WRF) models
  - Case et al. (2014; *IEEE TGRS*) documented model sensitivity and impacts
- NESDIS VIIRS daily global GVF product (Vargas et al. 2013; annual AMS meeting)
  - 0.04-deg resolution based on the VIIRS Enhanced Vegetation Index
  - We received a year of sample data from Sep 2012 to Sep 2013 from NESDIS
  - Conversion routines already developed to ingest VIIRS GVF into LIS and WRF
- Our analysis involves comparing the VIIRS GVF to SPoRT's MODIS GVF and the existing monthly GVF climatologies available to the LIS and WRF models

Background on Hyperspectral Infrared Profiles

- SPoRT has a history of assimilating hyperspectral infrared profiles into GSI/WRF for regional modeling studies
- Traditionally hyperspectral infrared radiance data are assimilated into global operational modeling systems
- The amount of radiance data assimilated is limited due to data thinning and because radiances are restricted to cloud-free fields of view
- The number of hyperspectral infrared profiles that can be assimilated is much higher
  - Partly cloudy scenes can be assimilated
  - Don't need to depend on a complex bias correction like radiance assimilation
- Satellite profiles are traditionally assimilated as rawinsonde observations and assigned rawinsonde errors which are unrepresentative for satellite profiles
- This project assesses the impact of assimilating NUCAPS profiles with appropriate error characteristics on a pre-fontal convection case

VIIRS GVF Results

Comparison Methodology

- LIS-Noah simulations (1 Sep 2012 to 1 Sep 2013) with four different GVF datasets:
  - NCEP/AVHRR GVF monthly climatology
  - MODIS-FPAR monthly climatology
  - SPoRT-MODIS real-time daily GVF
  - NESDIS-VIIRS real-time GVF
- Noah LSM driven by atmospheric input from hourly NLDAS-2 analyses
- Comparing GVF attributes in simulations; preliminary comparisons shown at right
- Sample WRF comparison over north-eastern Africa using NCEP vs. VIIRS GVF (Fig. 3)

SPoRT-MODIS shows low GVF anomaly in Upper Midwest while VIIRS has low GVF anomaly over Southern Plains, associated with the 2012 Summer drought

Fig. 1. U.S. Drought Monitor (4 Sep) and Sep 2012 Mean GVF.

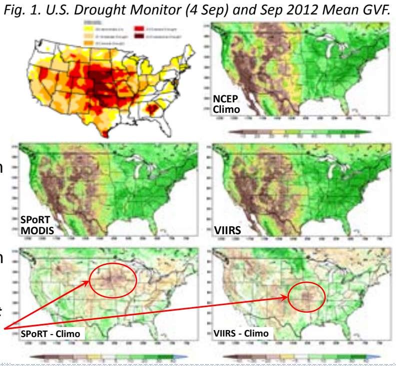
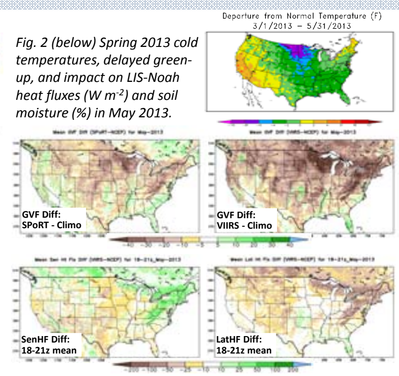
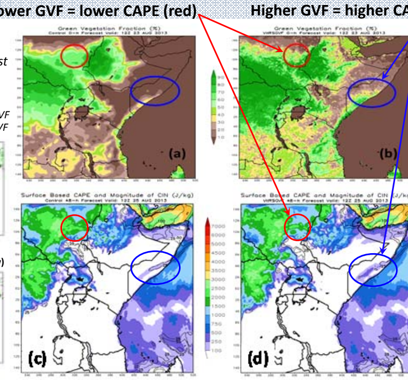


Fig. 2 (below) Spring 2013 cold temperatures, delayed green-up, and impact on LIS-Noah heat fluxes (W m^{-2}) and soil moisture (%) in May 2013.



(Fig. 3, right) WRF 12-km model simulated surface- based CAPE (J kg^{-1}) and CIN (J kg^{-1}) for 48-h fcst valid 1200 UTC 25 Aug 2013:
a) NCEP GVF climatology on 25 Aug
b) VIIRS GVF real-data
c) WRF model simulation with NCEP GVF
d) WRF model simulation with VIIRS GVF

Lower GVF = lower CAPE (red) **Higher GVF = higher CAPE (blue)**



Future Plans with NESDIS-VIIRS GVF

- Acquire entire POR for longer-term land surface modeling spin-up runs
- Establish real-time international LIS domains using real-time VIIRS GVF to support SPoRT/SERVIR collaboration
  - Mesoamerica/Caribbean
  - Eastern Africa
- Make real-time VIIRS GVF daily data to end-users running WRF model
  - NWS forecast offices
  - Research community
- *Plans contingent upon low-latency data access from NESDIS, especially for real-time applications*

NUCAPS Assimilation Results

- The default radiosonde errors (black line) in GSI are generally smaller than the Nallie et al. (2013) NUCAPS rms errors for temperature (Fig. 4) and water vapor (Fig. 5)
- To assign the NUCAPS profiles appropriate error values the following steps were taken:
  - NUCAPS profiles were appended to prepBUFR file with a new distinct code
  - GSI error tables were modified to contain NUCAPS errors
- Figure 6 shows the locations and color coded innovations where the NUCAPS profiles were assimilated at 852 hPa over a small sample domain

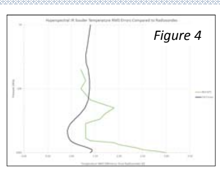


Figure 4

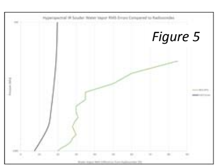


Figure 5

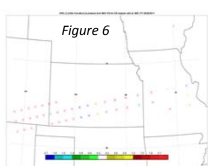


Figure 6

- Yellow/red (green/blue) regions represent locations where individual profiles have a positive (negative) impact on the final analysis

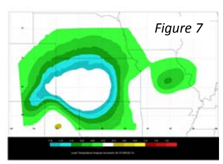


Figure 7

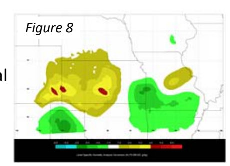


Figure 8

- Analysis increments show how much and where the background fields have been modified by assimilating observations
- 850 hPa temperature analysis increments (Fig. 7) shows the new analysis is cooler over a broad area
- 850 hPa moisture analysis increments (Fig. 8) show a varied change to the analysis with a region over western Kansas where the new analysis is more moist and a region over southwestern Missouri where the new analysis is drier

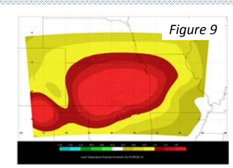


Figure 9

- 500 hPa temperature analysis increments show the new analysis was warmer than the original model background over much of the domain (Fig. 9)
- There was no change in the 500 hPa moisture field (not shown)

- Initial assimilation of NUCAPS profiles over a small test domain show:
  - Innovations larger than +/- 3 are present and represent where individual profiles impact the final analysis
  - The updated temperature analysis is cooler in the low levels and warmer in the mid-levels
  - The updated moisture analysis is modified more in the low levels with varied change
- Next steps include:
  - Running WRF with the new GSI analysis fields
  - Verifying forecast fields using WRF MET Tools
    - Accumulated precipitation
    - Temperature and dew point temperature at 2 m, 850 hPa, and 500 hPa